

Claims

1. A method for detecting faults, such as inclusions, within a transparent panel which is located in an ambient atmosphere, the method comprising:
directing light from a light source into an interface in contact with the
5 glass panel, the interface including one or more interface elements having a refractive index higher than the ambient atmosphere, at least some of the light passing through the interface into the glass panel and propagating within the glass panel along a path where total internal reflection is realized at surfaces of the glass panel; and
10 observing the light scattered by the faults and exiting the panel.
2. A method according to claim 1 in which the one or more interface elements include a body of flexible material which is pressed against the glass, whereby the body is deformed to increase the area of the panel with
15 which it is in contact.
3. A method according to claim 2 in which the body is composed of silicone rubber.
- 20 4. A method according to claim 1, claim 2 or claim 3 in which the interface includes a plurality of the interface elements, each having a refractive index greater than the ambient medium.
5. A method according to any preceding claim in which the interface
25 further includes a liquid coupling layer interposed between the panel and the one or more interface elements.
6. A method according to claim 5 in which the liquid coupling layer is substantially composed of water.

7. A method according to any preceding claim in which the one or more interface elements include at least one interface element including a portion which has a generally prism-shaped cross-section when viewed in a direction perpendicular to the light path.

8. A method according to any preceding claim in which the interface and light source are moved over the panel to vary the portion of the panel which is illuminated by the light.

9. A method according to claim 8 in which the interface includes at least one interface element which rolls over the surface of the panel when the interface is moved.

10. A method according to claim 9 in which the interface which rolls has circular cross-section when viewed in a direction perpendicular to the light path.

11. A method according to claim 9 in which the interface element which rolls is maintained in a configuration which is elongate in the direction in which it rolls, the configuration including a substantially flat portion facing the panel, the light source providing the light along the length of the substantially flat portion.

12. A method according to claim 10 or claim 11 in which the light source moves in fixed positional relationship with the interface element having a circular cross-section.

13. A method according to any preceding claim in which the interface includes at least one interface element which is a flexible wave guide .

14. A method according to any preceding claim in which at least a portion of the surface of the interface, other than the portions through which the light beam enters the interface and the portion of the interface which contacts the panel, has a coating for reflecting light.

15. A method according to any preceding claim in which the ambient medium is air.

16. A method according to any of preceding claim in which the scattered light is observed by a human operator.

17. A method according to any of claims 1 to 15 in which the scattered light is observed by one of more electronic detectors or cameras.

18. A method according to claim 17 in which the one or more electronic detectors or cameras are electronically coupled to an automated image analysis system.

19. A method according to claim 18 in which the automated image analysis system determines from the output of the one or more detectors or cameras the type of fault which scattered the light.

20. A method according to claim 19 in which the automated image analysis system discriminates the defects, air bubbles and solid inclusions etc based on their size, shape and reflectivity.

21. A method according to any of claims 17 to 20 in which there are a plurality of the cameras and a corresponding plurality of the light sources, the

cameras being arranged to observe the illuminated region of the panel from different directions.

22. A method according to claim 21 when dependent on any of claims 18
5 to 20, in which the automated image analysis system determines the position of a detected inclusion in the thickness direction of the panel.

23. A method according to any preceding claim in which the transparent
10 panel is glass.

24. A method according to any of claims 1 to 22 in which the transparent
panel is a transparent polymer.

25. An apparatus for detecting faults, such as inclusions, within a
15 transparent panel which is located in an ambient atmosphere, the apparatus comprising:

a light source;

an interface including one or more interface elements having a
refractive index higher than the ambient atmosphere and transparent to light
20 generated by the light source; and

light source support means for locating the light source in a positional
relationship to the interface such that when the interface is contacting the
panel, light generated by the light source is transmitted through the interface
into the panel and propagates within the panel along a path where total
25 internal reflection is realized at surfaces of the panel.

26. An apparatus according to claim 25 in which the one or more interface
elements include a body of flexible material, whereby upon pressing the body
against the panel the body is deformed to conform to the surface of the panel.

27. An apparatus according to claim 26 in which the body is composed of silicone rubber.

28. An apparatus according to claim 25, claim 26 or claim 27 in which the
5 interface includes a plurality of the interface elements, each having a refractive index greater than the ambient medium.

29. An apparatus according to any of claims 25 to 28 further including
10 means for providing the interface with a liquid coupling layer interposed between the panel and the one or more interface elements.

30. An apparatus according to any of claims 25 to 29 in which the one or
more interface elements include at least one interface element including a
portion which has a generally prism-shaped cross-section when viewed in a
15 direction perpendicular to the path of light generated by the light source.

31. An apparatus according to any of claims 25 to 30 in which the interface
is adapted to be moved over the panel to vary the portion of the panel which
is illuminated by the light.
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32. An apparatus according to claim 31 in which the interface includes at
least one interface element adapted to roll over the surface of the panel when
the interface is moved.

25 33. An apparatus according to claim 32 in which the interface element adapted to roll has a circular cross-section.

34. An apparatus according to claim 32 further including means for
maintaining the interface element which is adapted to roll in a configuration
30 which is elongate in the direction in which it rolls and which includes a

substantially flat portion, the light source being arranged to provide the light along the substantially flat portion.

35. A method according to any of claims 31 to 34 in which the light source
5 support means is arranged, as the interface moves over the surface of the panel, to move the light source maintaining fixed positional relationship with the interface.

36. An apparatus according to any of claims 25 to 35 in which the interface
10 includes at least one interface element which is a flexible wave guide sheet.

37. An apparatus according to any of claims 25 to 36 in which at least a
portion of the surface of the interface, other than the portions through which
the light beam enters the interface and the portion of the interface which
15 contacts the panel, has a coating for reflecting light.

38. An apparatus according to any of claims 25 to 37 further including one
of more electronic detectors for detecting the scattered light.

20 39. An apparatus according to claim 38 further including an automated
image analysis system arranged to receive data output by the one or more
electronic detectors.

40. An apparatus according to claim 39 in which the automated image
25 analysis system is arranged to determine from the output of the one or more
detectors the type of fault which scattered the light.

41. An apparatus according to claim 40 in which the automated image
analysis system is arranged to discriminate air bubbles from solid inclusions
30 based on their size, shape and/or reflectivity.

42. An apparatus according to any of claims 38 to 41 in which there are a plurality of the cameras and a corresponding plurality of the light sources, the cameras being arranged to observe the illuminated region of the panel from
5 different directions.

43. An apparatus according to claim 42 when dependent on claim 39, claim 40 or claim 41, in which the automated image analysis system is arranged to determine the position of a detected inclusion in the thickness direction of the
10 panel.